HIGHWAY RESEARCH REPORT

EVALUATION OF EROSION FROM CHEMICALLY TREATED SLOPES LAKE TAHOE BASIN

LUTHER PASS

INTERIM REPORT

June, 1973

STATE OF CALIFORNIA

BUSINESS AND TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMEN

RESEARCH REPORT

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16. ABSTRACT

This experiment evaluated the effectiveness of two chemical slope treatments in reducing slope erosion through a winter season. Both chemicals were copolymer dispersions and formed a transparent crust about 1/4" thick on the surface of the slope.

Three ten foot by fifteen foot experimental slope erosion test plots were constructed on a cut slope at elevation 7,000 feet on Highway 89, Post Mile 2.4, El Dorado County, Lake Tahoe Basin. Sediment troughs were attached to the bottom of each plot to collect the eroded sediment. Two of the test plots were chemically treated with commercial plastic sprays while the third plot was untreated.

A precipitation gage was installed at the test site and continuous precipitation data were recorded. During the period October 15, 1971 to October 26, 1972, erosion from each of the three plots was collected at various intervals and analyzed to determine the relative amounts and characteristics of the eroded material. The plots were under a canopy of snow for approximately four months during the study.

The data indicates that chemical slope treatment can be effective in reducing slope erosion through a winter season.

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Chemical slope treatment, test plots, sediment trough, precipitation, sediment, erosion control.	Unlimited

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STATE OF CALIFORNIA—TRANSPORTATION AGENCY
RONALD REAGAN, Governor

DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT
5900 FOLSOM BLVD., SACRAMENTO 95819

June 1973
Interim Report

Mr. Sam Helwer
District Engineer

Dear Sir:

Submitted herewith is a report titled:

EVALUATION OF EROSION

FROM CHEMICALLY TREATED SLOPES

LAKE TAHOE BASIN

LUTHER PASS

Study made by . . . . .Environmental Improvement Section

Under general supervision of . . . . .Earl Shirley

Work supervised by .Richard Howell

Report prepared by . . . . .Mike Quint

Assistance . . . . Ron Mearns & Don Foster

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

Attachment

ACKNOWLEDGEMENTS

This project was conducted at the request of District 03. The assistance of Mr. Don Foster of District 03 is greatly appreciated.

The assistance of Mr. Ronald Mearns of the Materials and Research Department Foundation Section in the selection of the chemical treatments, their application, and the collection of the sediment data during the Fall of 1972 is appreciated. Field assistance by Messers. Robert Breazile, Eric Torguson and Richard Wasser is also sincerely appreciated. The Materials and Research Shop Services, under the direction of Floyd Martin, fabricated the sediment troughs.

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OBJECTIVE

The purpose of this study is to evaluate the effectiveness of selected chemical slope treatments for temporary erosion control in a freeze-thaw environment.

INTRODUCTION

In September 1971 the Materials and Research Department was requested by District 03 to furnish materials and technical assistance for an experimental slope erosion control project using chemical spray treatments. The treatments were to be placed on a large cut slope (approximately 100 feet high by 400 feet long) on highway 89 near Luther Pass in the Lake Tahoe Basin. In the past, this slope required frequent maintenance to clear eroded sediment. Boulders rolling down the slope onto the highway have posed a safety hazard. A slope erosion survey made in the summer of 1971 revealed that approximately 150 tons of sediment are eroded annually from the slope[1].

Prior to applying the chemical treatments, a top of cut ditch was installed and loose rock and tree limbs from the slope face were removed. To preserve the ecology of the area, mules were used to haul the rock for the top of cut ditch lining[3]. Three test plots were then established on the slope face. The two outside plots were sprayed with chemicals in the fall of 1971 and the middle test plot was left untreated and served as a control section. The chemical treatments were Curasol A.H. applied at a rate of 96 gal./acre (40:1 dilution) and Aerospray 70 using a rate of 100 gal./acre (20:1 dilution).

Sediment from each of the test plots was collected in troughs located at the base of each plot. The samples were analyzed for dry weight, specific gravity, and particle size gradation. Continuous precipitation information was obtained from a gage located above the cut.

Sediment from each of the three test plots was analyzed to compare quantities and characteristics of eroded material and the effects of precipitation on erosion rates.

CONCLUSIONS

The data obtained for the period October 1971 to September 1972 indicates that the Curasol A.H. and Aerospray 70 slope treatment did reduce erosion rates in relation to the untreated test plot. However, this test data was gathered from only 450 square feet of the total 31,350 square feet of slope face and therefore should be viewed in this respect.

Through the 12 month period of the study there was a 70% reduction in erosion (relative to the control plot) on the test plot treated with Curasol A.H. and there was a 29% reduction in erosion on the plot treated with Aerospray 70. However, the spring and summer erosion data from the Aerospray 70 test plot was influenced by underground water seepage which did not affect the other plots. Any significant groundwater seepage may cause a serious loss in the effectiveness of chemical treatments.

DATA SUMMARY

The erosion and climatological data were analyzed to investigate the reduction in erosion from the chemically treated slopes and the relationship between erosion and precipitation.

Erosion Reduction on Chemically Treated Slopes

The erosion data for this study is summarized below:

Test Plot No.	Treatment	Sediment Dry Wt. (lbs.) Pre-Winter 10-15 to 12-7-71	Post-Winter 3-10 to 10-26-72	Total
1	Curasol A.H.	28	173	201
2	None	207	468	675
3	Aerospray 70	38	*439	477

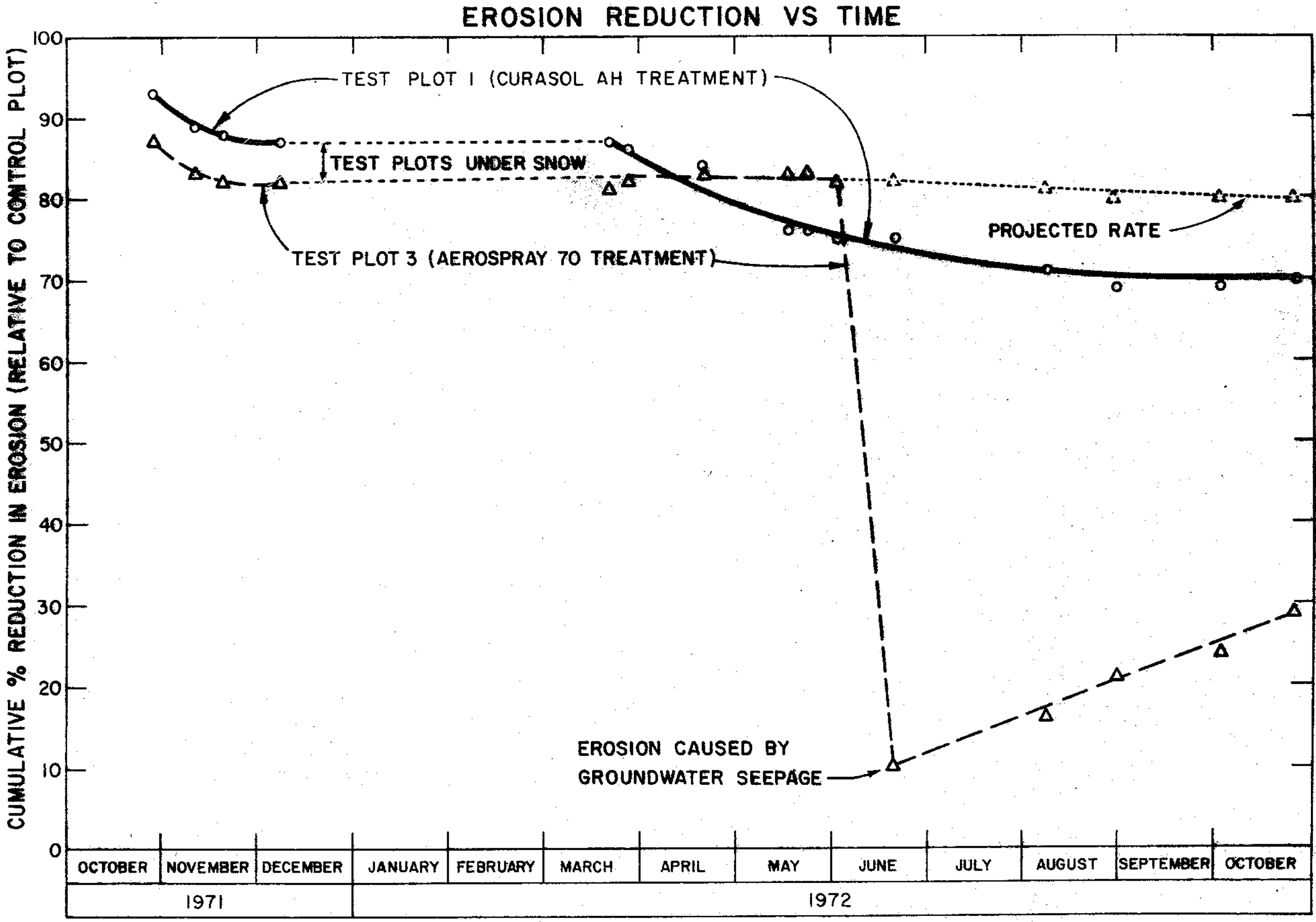
The reduction in erosion from the two chemically treated test plots relative to the untreated plot is shown in Figure 1.

At the beginning of the experiment, the Curasol A.H. treatment reduced erosion by about 90% while at the end of 12 months the reduction was down to about 70%. The gradual decrease in erosion reducing effectiveness was probably caused by the degradation of the chemical treatment.

The Aerospray 70 treatment was about 85% effective in reducing erosion at the beginning of the experiment and within a short period decreased to about 30%. However, the rapid decline was attributable to significant groundwater seepage which did not appear on the other plots. If this effect was neglected, the projected erosion reducing affect of Aerospray 70 at the end of 12 months is 80%.

*See text for explanation.

Figure 1



EROSION REDUCTION VS TIME
CUMULATIVE % REDUCTION IN EROSION (RELATIVE TO CONTROL PLOT)
100
90
80
70
60
50
40
30
20
10
0
TEST PLOT 1 (CURASOL AH TREATMENT)
TEST PLOTS UNDER SNOW
TEST PLOT 3 (AEROSPRAY 70 TREATMENT)
PROJECTED RATE
EROSION CAUSED BY
GROUNDWATER SEEPAGE
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
1971
1972

Erosion and Precipitation

The quantities of erosion attributed to the various types of precipitation are tabulated in Table 1, which indicates that the major portion of the erosion from all three test plots was caused by rain. Wind-borne erosion sediments were not measured in this study.

TABLE 1

Erosion and Precipitation Type

Precipitation Type	Test Plot 1 (Curasol A.H.) Sediment (lbs.)	Test Plot 1 (Curasol A.H.) % of Total	Test Plot 2 (Control) Sediment (lbs.)	Test Plot 2 (Control) % of Total	Test Plot 3 (Aerospray 70) Sediment (lbs.)	Test Plot 3 (Aerospray 70) % of Total
Rain	100	50	255	38	*406	85
Rain & Snow	81	40	238	35	41	9
Snow	20	10	182	27	30	6
Total	201	100	675	100	477	100

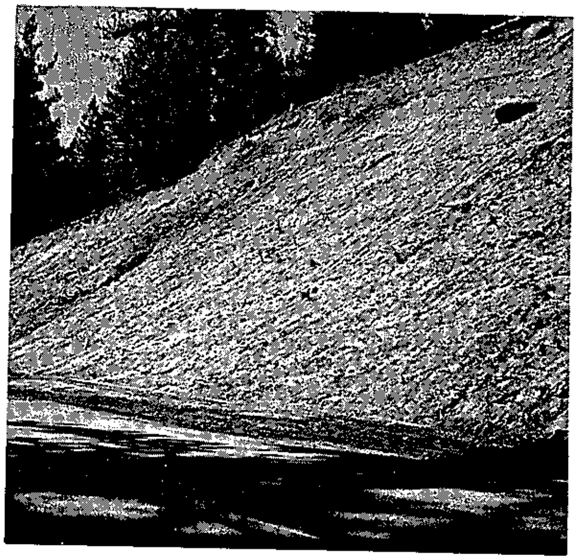
Most of the erosion from the Aerospray 70 test plot attributed to rain was due to the 356 pounds of eroded sediment collected on June 21, 1972. Field observations indicated that the major portion of this erosion was caused by groundwater seepage.

INVESTIGATION

Test Slope

The test slope is located between P.M. 2.36 and P.M. 2.44 on Route 89 in El Dorado County. It is a large cut slope on the north side of the road which has shown a significant amount of erosion since the highway was first constructed in 1959. The South Tahoe Public Utility District constructed a pipe line, for transmission of treated waste water from South Lake Tahoe to Alpine County, at the base of this cut in 1968. This resulted in some disturbance of the lower portion of the slope.

*See text for explanation.



Test Slope (9-21-71)

The test slope is approximately 400 feet long and 100 feet high at the highest point, and covers approximately 3/4 of an acre.

The configuration of the slope face is illustrated in Figure 2. The cut face slope is about 1.5 feet horizontal to 1.0 foot vertical. The slope is facing South 40° East.

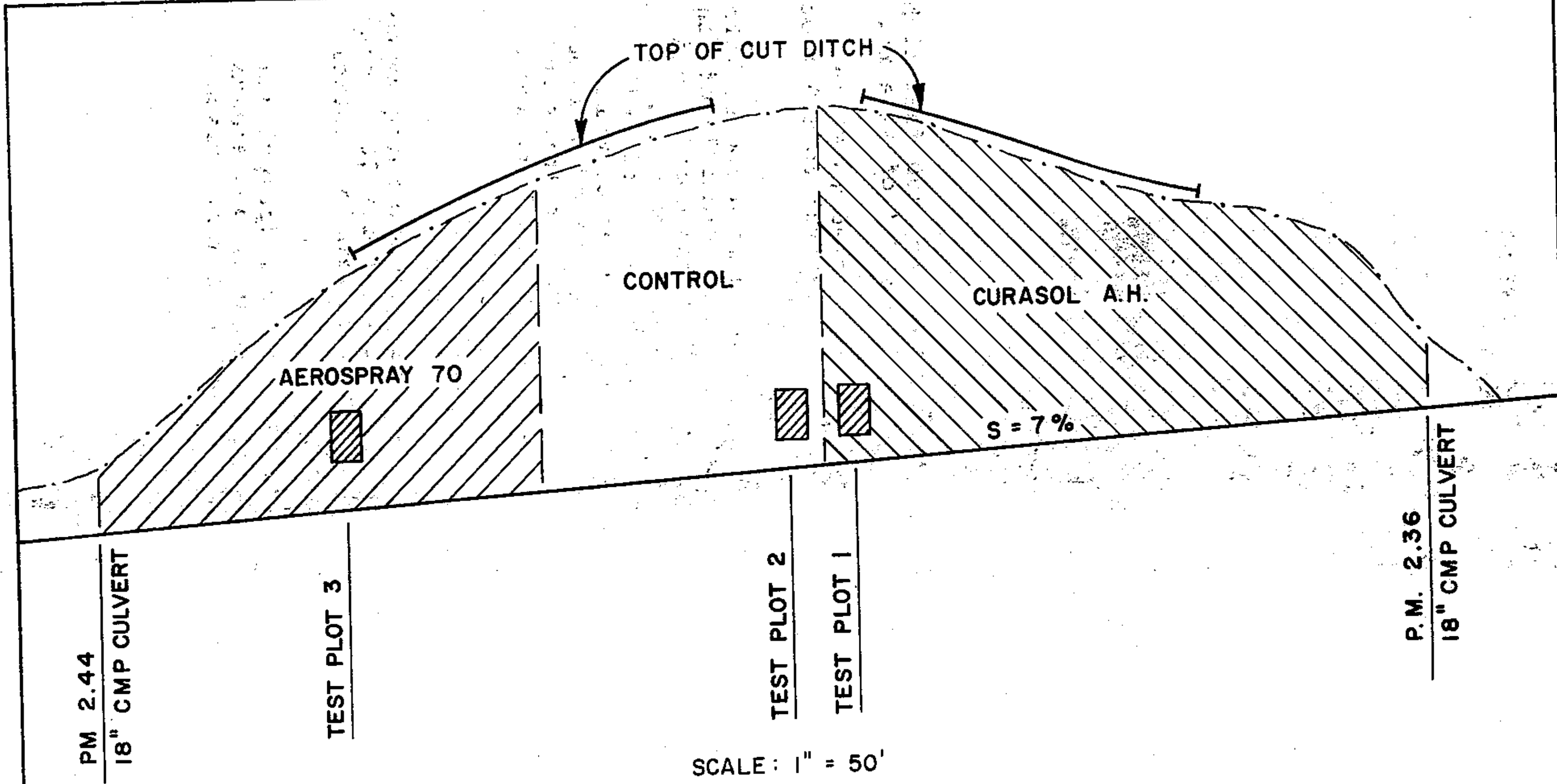
In general the soil at the test slope location is a loose, buff colored quarternary glacial deposit consisting primarily of sand and silt size fragments with scattered subrounded cobbles and boulders. Seepage from groundwater was evident about 2/3 of the way up the slope in the Fall of 1971 and Spring of 1972. Vegetation on the cut slope face is extremely sparse, while vegetation on the area above the cut face consists of numerous conifers and brush. Humus on undisturbed ground is thick and low ground cover is predominant. The slope of the hill above the cut slope face is about 2 to 1.

Chemical Treatment

The chemicals evaluated as to their efficacy in providing temporary erosion control were Curasol A.H. and Aerospray 70. These chemicals were selected on the basis of prior erosion control results in other areas of the State.

Both Curasol A.H. and Aerospray 70 are copolymer (polyvinyls and polyethylenes) dispersions and are similar in appearance and odor. In concentrated form they resemble a white viscous

Figure 2



SCALE: 1" = 50'

SLOPE FACE AREA (PM 2.36 TO 2.44) = 31,350 S.F. = 0.72 ACRE
EACH TEST PLOT = 10' x 15' = 150 S.F.
ELEVATION = 7,000 FT. ABOVE M.S.L.

STATE OF CALIFORNIA
DIVISION OF HIGHWAYS
MATERIALS & RESEARCH DEPARTMENT
ENVIRONMENTAL IMPROVEMENT SECTION

SLOPE FACE CONFIGURATION AND TEST PLOT LOCATIONS

LUTHER PASS SLOPE TREATMENT
LAKE TAHOE BASIN
ROAD 03-ED-89, PM 2.4

5-72

casein glue and weigh about 10% more than water. After application they form a crust about 1/4" thick on the surface of the slope. Curasol A.H. forms a semiflexible crust and Aerospray 70 forms a semirigid crust.

Curasol A.H. is made in Germany by the American Hoechst Corporation. Aerospray 70 was developed by Union Carbide under the name DCA 70 and is marketed under the name of Aerospray 70 by American Cyanamid. The price in Northern California for Curasol A.H. in May 1972 was about $3.35 per gallon and the price for Aerospray 70 at this time was about $2.50 per gallon, assuming purchase of quantities less than 200 gallons.

Curasol A.H. was applied to the easterly end of the slope (approximately 1/4 acre) at the rate of 96 gallons per acre and using a dilution rate of 40 to 1. This treatment was applied on September 28, 1971.

Aerospray 70 was applied to the westerly end of the slope (approximately 1/4 acre) at the rate of 100 gallons per acre and using a dilution rate of 20 to 1. This treatment was applied on October 12, 1971.

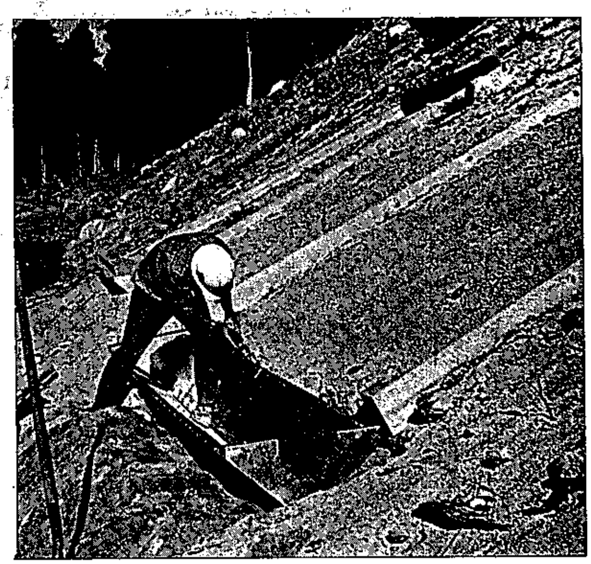
In both cases the treatments were applied with a Finn Hydroseeder. Three men were required to do the work. The treatments extended back over the rounded top of slope to prevent water from undercutting the upper portion of the treatment.

The estimated costs (material, labor, and equipment) for the treatments, applied at the rates noted above, are about $550 per acre for the Curasol and about $450 per acre for the Aerospray. These costs do not include travel time, which is estimated at about $50 per hour.

Test Plots and Sediment Troughs

Three 10-foot by 15-foot test plots were installed on the test slope. Sediment troughs were attached at the bottoms of the test plots to collect the erosion from each plot. Upslope erosion was deflected around the sides of the test plots by deflector boards installed at the top of each test plot. The troughs and plots were designed in accordance with the procedure outlined in "Sediment Trough Method of Estimating Erosion from Highway Slopes"(2).

The locations of the plots on the test slope face are illustrated in Figure 2. A photographic history of the test plots is shown in the Appendix.



Installing sediment trough
at bottom of test plot.
(10-14-71)

Sediment Analysis

Sediment eroding from each of the three test plots was collected in the sediment troughs. During the spring runoff, an attempt was made to collect the sediment after each major storm. The sediment samples were analyzed for dry weight, specific gravity and particle size distribution.

The combined gradation curves for each plot are illustrated in Figure 3. An analysis of these curves reveals the following information:

	Sediment Particle Diameter		
	Test Plot 1	Test Plot 2	Test Plot 3
D_{90} (90% is finer than)	3/8"	1/2"	7/16"
D_{50} (50% is finer than)	700 microns	590 microns	610 microns
% Finer than 62.5 microns*	5%	6%	11%

*Clay and silt size particles.

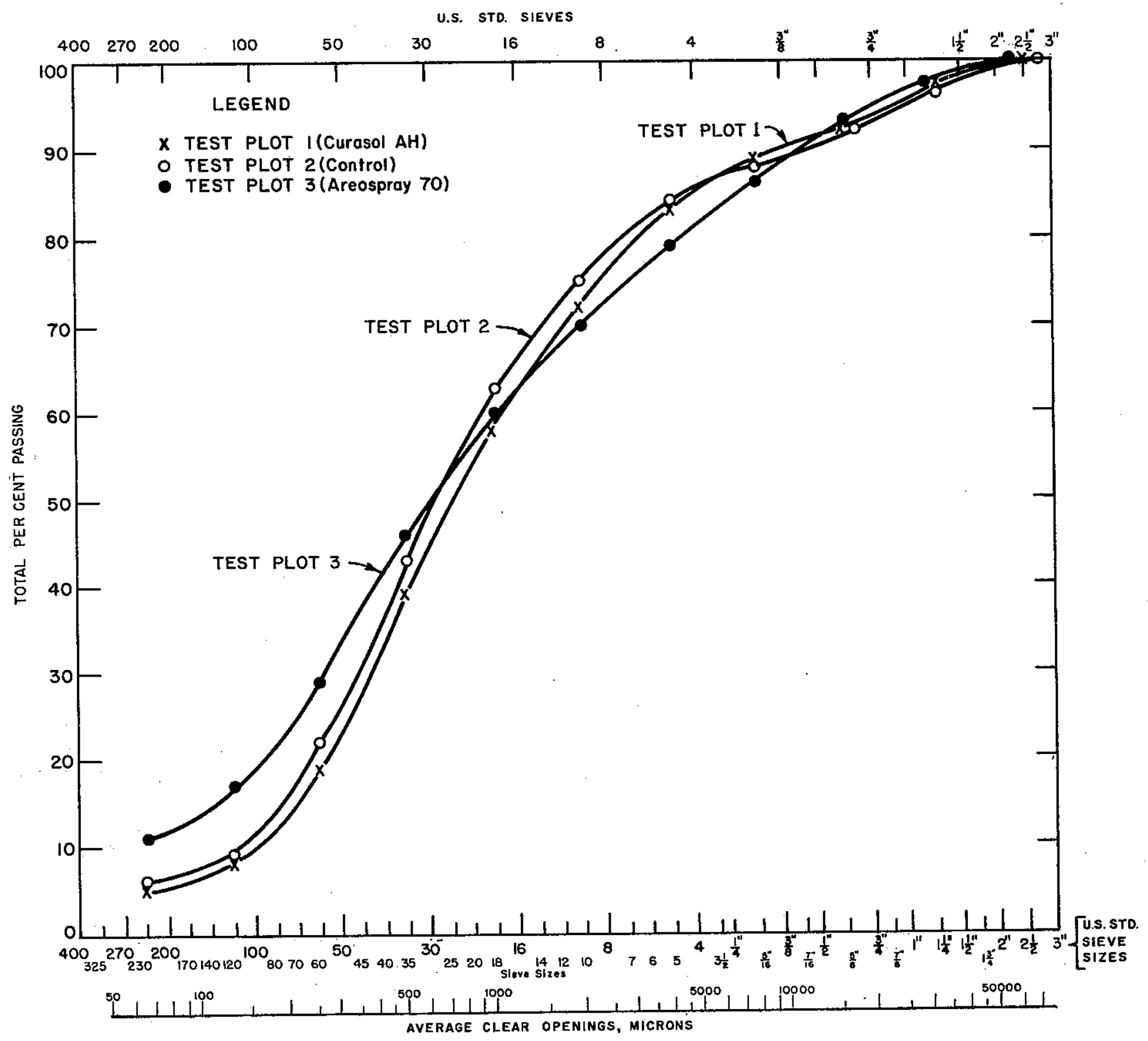
The average specific gravity of the sediment was 2.68.

Figure 3

GRADING ANALYSIS

TEST PLOTS 1,2 AND 3

LUTHER PASS SLOPE TREATMENT
LAKE TAHOE BASIN
ROAD 03-ED-89, PM 2.4



A.A.S.H.O. DESIGNATION - M92 A.S.T.M. DESIGNATION E11, (SQUARE OPENINGS)

Climatology

Precipitation at the test slope location was measured with a Weather Measure P511P propane heated precipitation gage and recorded on a continuous chart by a Weather Measure P522 long term event recorder. Precipitation type (rain or snow) was determined from South Lake Tahoe Airport Weather records and by discussions with Division of Highways Maintenance Department personnel located at South Lake Tahoe.

Precipitation Gage and
Snow Gage (10-14-71)

A daily precipitation record for the period October 15, 1971 to October 31, 1972 is shown in the Appendix. Total precipitation for this period was 27.89 inches. The severe rainstorms with an intensity greater than 0.10 inch/hour occurred 31 times. The maximum intensity recorded was 0.92 inches/hour and this occurred on May 26, 1972. Rainfall intensities are shown in the Appendix.

The first measureable snow was recorded on November 18, 1971 and measured 0.5 feet. Maximum snow depth was 4.3 feet on December 29, 1971. The snow was essentially gone by March 10, 1972.

Temperature ranges were recorded as listed in Table 2 below:

TABLE 2

TEMPERATURE RANGE RECORD

Period	Temperature Range (°F) Low	High
October 27 to November 10, 1971	5	66
November 10 to November 18	8	60
November 18 to December 7	7	56
December 7 to December 29	2	58
December 29 to February 2, 1972	0	62
February 2 to March 21	9	67
March 21 to March 28	9	62
March 28 to April 7	17	61
April 7 to April 21	12	61
April 21 to May 17	14	71
May 17 to May 23	25	54
May 23 to June 2	29	71
June 2 to June 23	28	73
June 23 to August 9	30	88
August 9 to August 18	36	85
August 18 to September 27	24	82
September 27 to November 6, 1972	14	65

The temperatures were measured with a Weather Measure Model TM45 maximum-minimum thermometer, located in the precipitation gage recorder box.

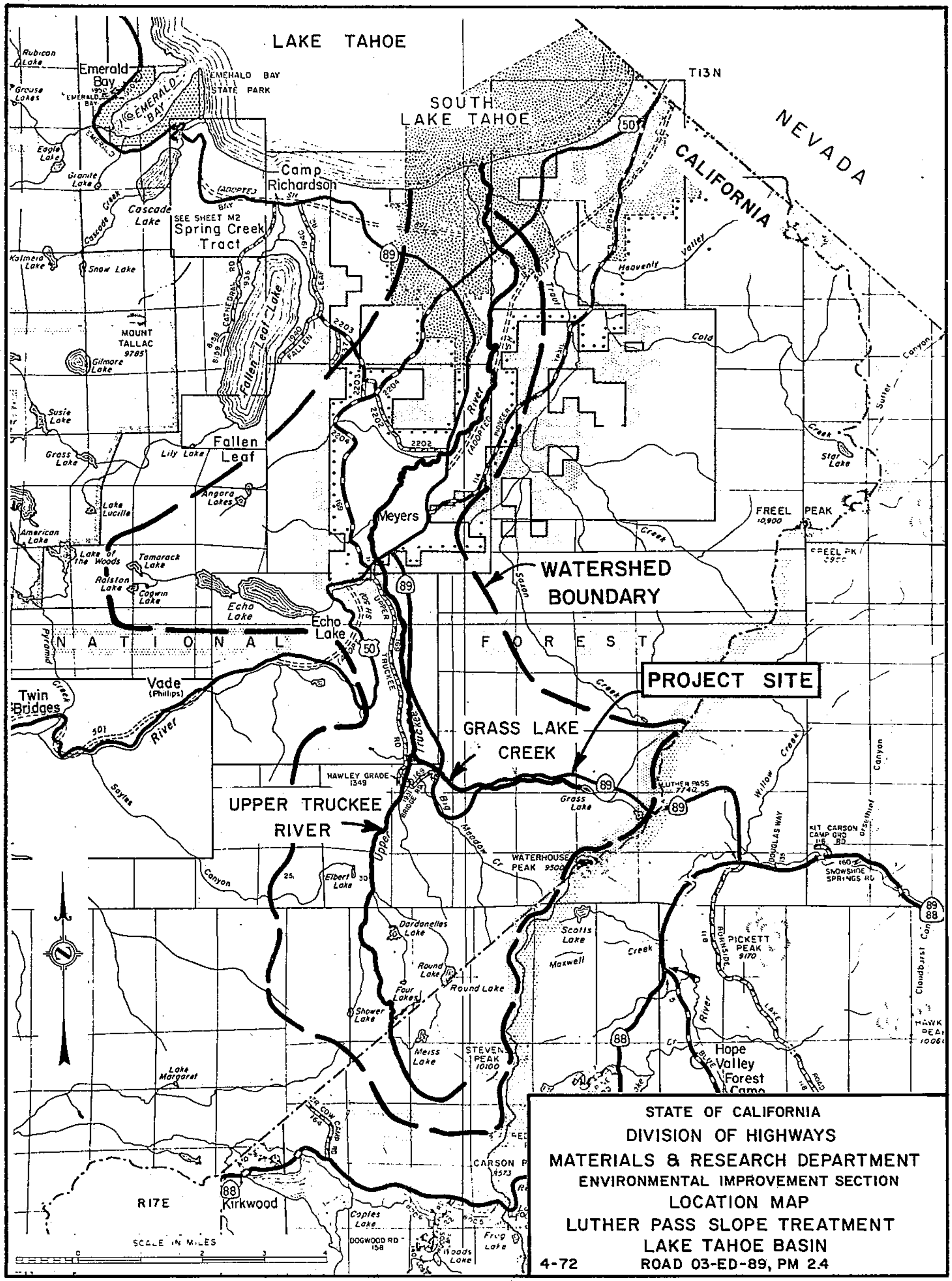
REFERENCES

1. "Slope Erosion Transects, Lake Tahoe Basin," Howell, R. B.; Shirley, E. C.; Skog, J. B.; Materials and Research Department, M&R Report No. 657078-1, July 1971.

2. "Sediment Trough Method of Estimating Erosion from Highway Slopes," Quint, M.; Howell, R. B.; Shirley, E. C.; Skog, J. B.; Materials and Research Department, 1973 (report in draft).

3. "Mule Power Aids Ecology," The Sacramento Bee, October 6, 1971, Page C3.

APPENDIX



STATE OF CALIFORNIA
DIVISION OF HIGHWAYS
MATERIALS & RESEARCH DEPARTMENT
ENVIRONMENTAL IMPROVEMENT SECTION
LOCATION MAP
LUTHER PASS SLOPE TREATMENT
LAKE TAHOE BASIN
4-72 ROAD 03-ED-89, PM 2.4

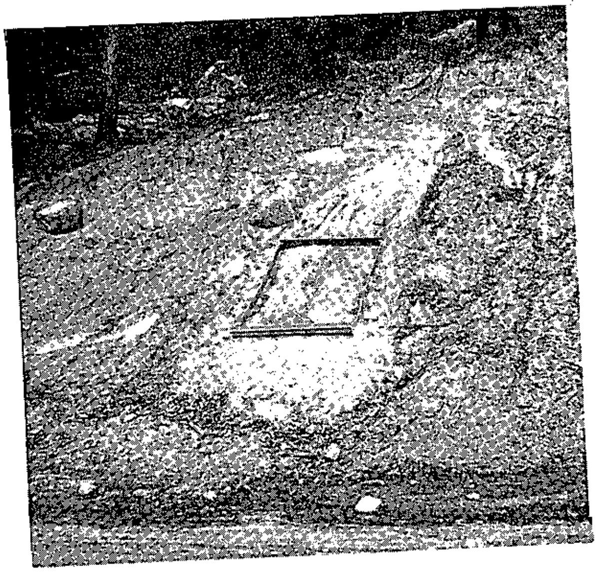


Plate 1

Slope for Test Plot 3
Prior to treatment.
(9-21-71)

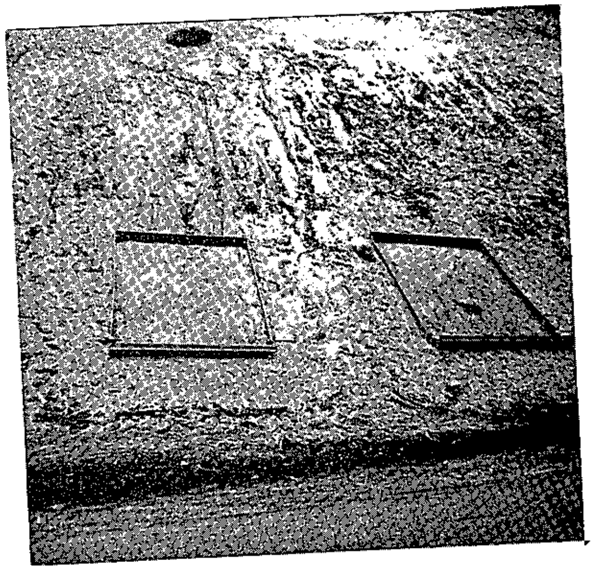


Plate 2

Slope for Test Plots 1 & 2
Prior to treatment.
(9-21-71)

Plate 3

Test Plot 3
(10-14-71)
Start of experiment.

Plate 4

Test Plot 2 and Test Plot 1
(10-14-71)
Start of experiment.

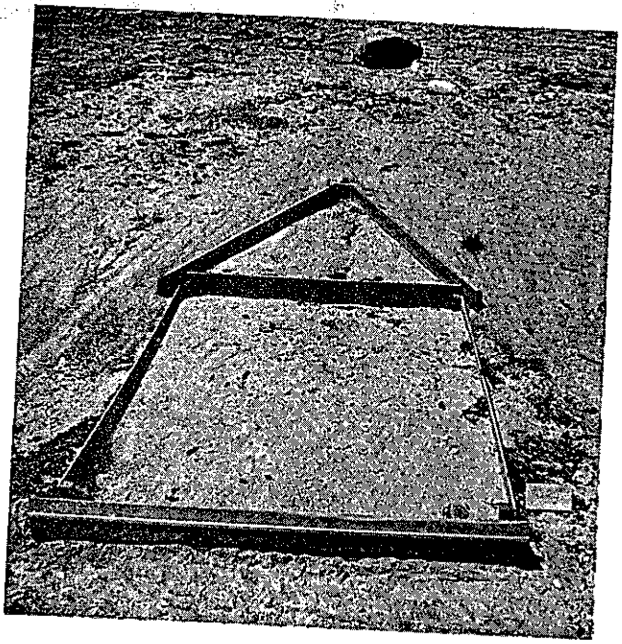


Plate 5

Test Plot 2
(11-10-71)
No visible erosion.

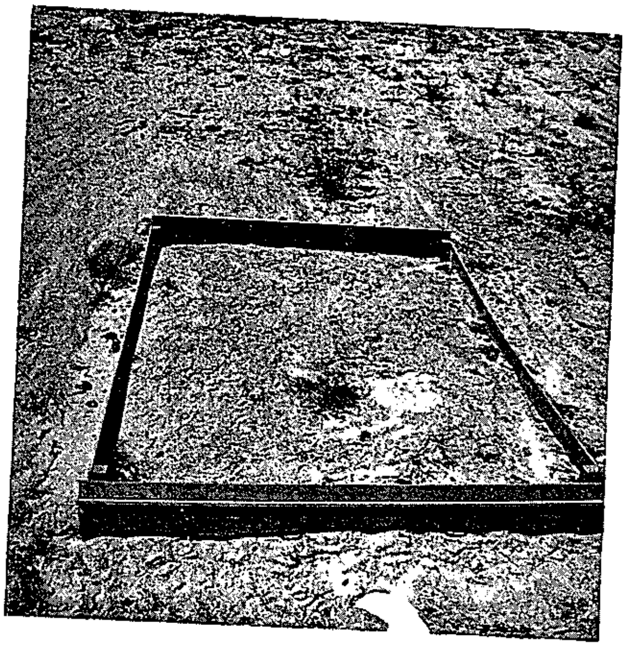


Plate 6

Test Plot 1
(11-10-71)
No visible erosion.

Plate 7

Test Plot 3
(11-18-71)
Under light blanket
of snow (6" $\pm$).

Plate 8

Test Plot 2 and Test Plot 1
(11-19-71)
Under light blanket
of snow (6" $\pm$).

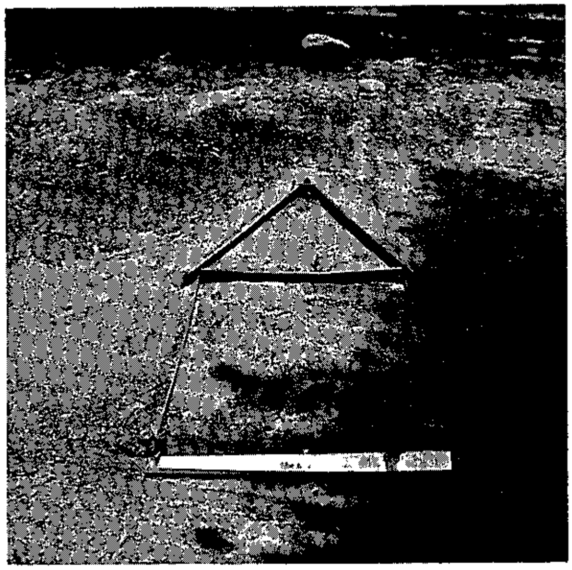


Plate 9

Test Plot 2
(3-12-72)
Light surface erosion visible.

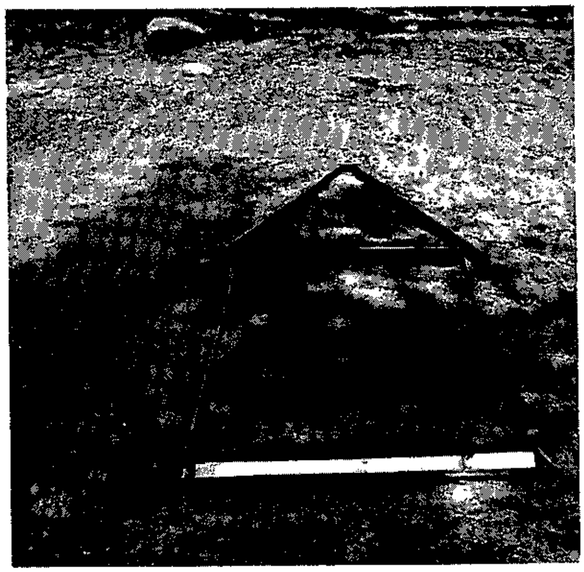


Plate 10

Test Plot 1
(3-12-72)
Light surface erosion visible.

Plate 11

Test Plot 3
(3-12-72)
Note underground water seepage, and severe erosion to the left of the test plot.

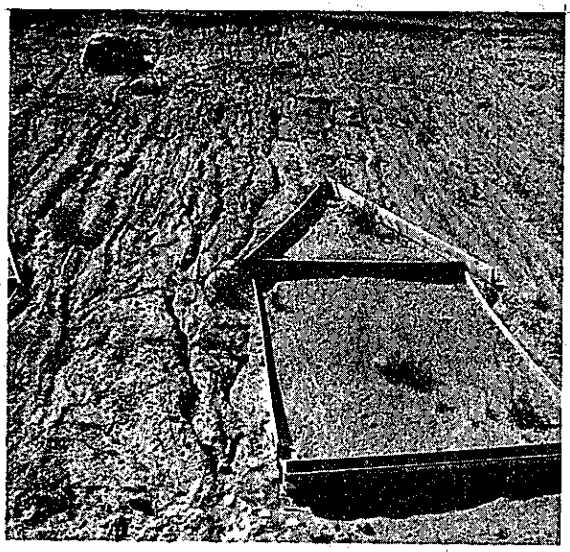


Plate 12

Test Plot 1
(6-21-72)
Light surface erosion visible.
Note severe erosion outside
left side of Plot 1.

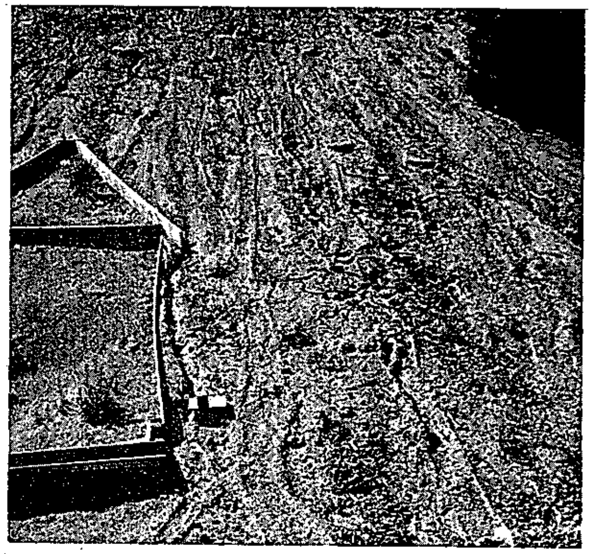


Plate 13

Test Plot 1
(6-21-72)
Note light erosion
right of Plot 1.

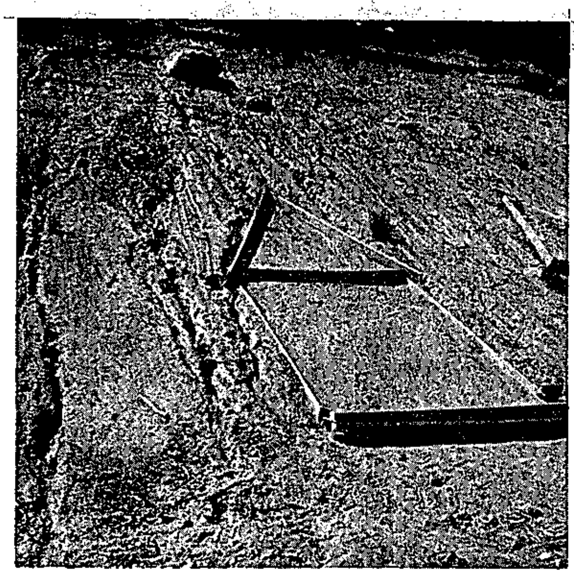


Plate 14

Test Plot 2
(6-21-72)
Light surface erosion visible.
Note severe erosion left of
Plot 2.

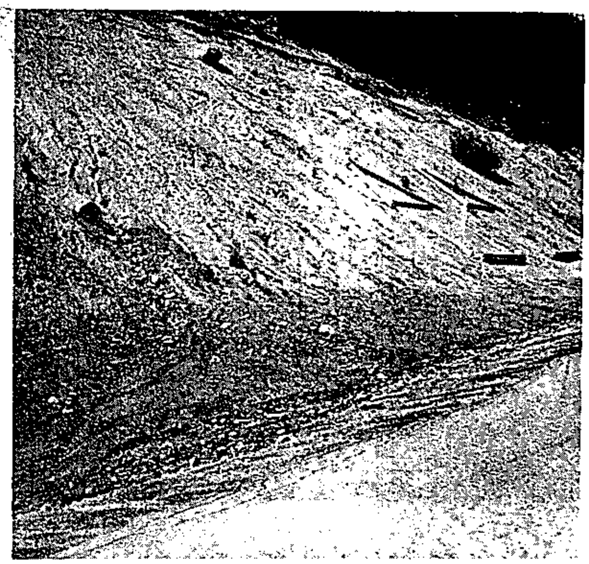


Plate 15

Severe erosion from area
between Plot 2 and 3
accumulated at the bottom
of the slop.
(6-21-72)

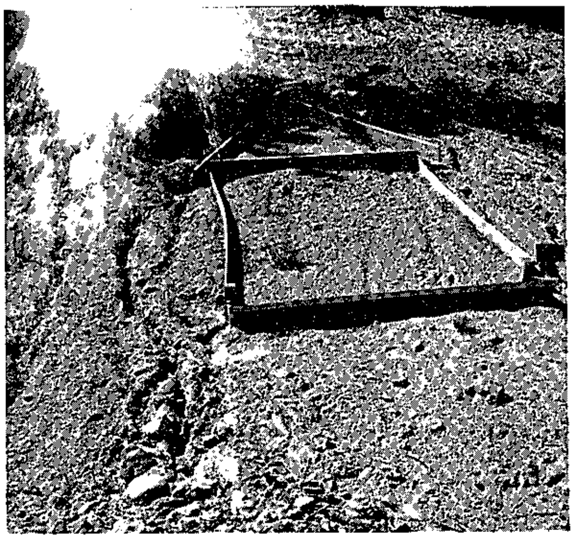


Plate 16

Test Plot 3
(6-21-72)
Note severe erosion outside left side of Plot 3.

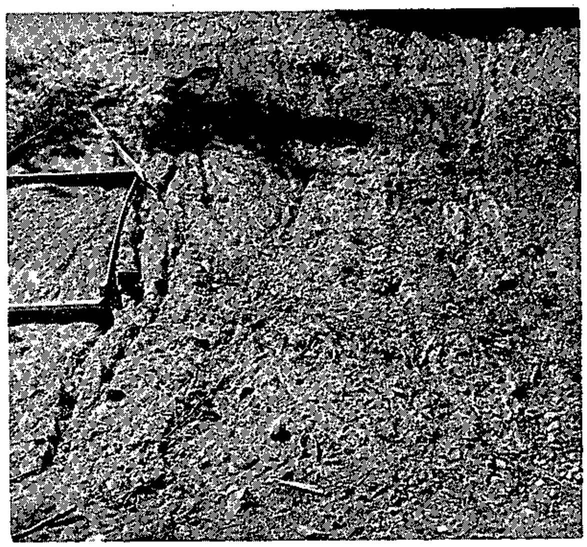


Plate 17

Test Plot 3
(6-21-72)
Note severe erosion outside right side of Plot 3.

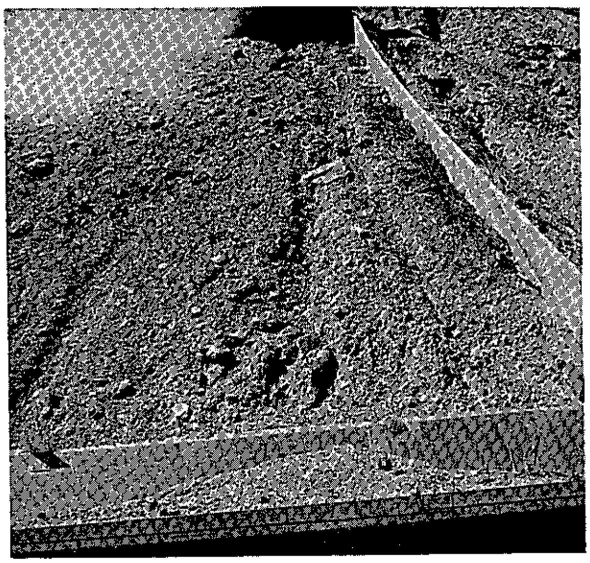


Plate 18

Test Plot 3
(6-21-72)
Severe erosion near right side of Plot 3.

TABLE A

Erosion Reduction* on Chemically Treated Slopes

PERIOD	Sediment (Lbs. Dry Wt.) Plot 2 (Control) Wt	Plot 2 (Control) ΣWts	Plot 1 (Curasol) Wt	Plot 1 (Curasol) ΣWts	Plot 3 (Aerospray) Wt	Plot 3 (Aerospray) ΣWts	Curasol Red.	Curasol ΣRed.	Aerospray Red.	Aerospray ΣRed.	Cummulative % Reduction* Curasol	Cummulative % Reduction* Aerospray
TEST PLOTS IN SERVICE ON 10-15-71												
10-15 to 10-27-71	50.8	50.8	3.5	3.5	6.6	6.6	47.3	47.3	44.2	44.2	93	87
10-27 to 11-10-71	131.5	182.3	16.3	19.8	23.7	30.3	115.2	162.5	107.8	152.0	89	83
11-10 to 11-18-71	22.2	204.5	5.6	25.4	6.3	36.6	16.6	179.1	15.9	167.9	88	82
11-18 to 12-7-71	2.1	206.6	2.4	27.8	1.6	38.2	-0.3	178.8	0.5	168.4	87	82
Test plots were covered with snow between 11-18-71 and early March 1972. In early March the sediment troughs were damaged by the melting snow and the sediment was not collected. The troughs were repaired and in service on 3-10-72.												
3-10 to 3-21-72	17.1	223.7	1.7	29.5	3.3	41.5	15.4	194.2	13.8	182.2	87	81
3-21 to 3-28-72	25.0	248.7	6.5	36.0	3.4	44.9	18.5	212.7	21.6	203.8	86	82
3-28 to 4-21-72	46.1	294.8	12.0	48.0	6.3	51.2	34.1	246.8	39.8	243.6	84	83
4-21 to 5-17-72	119.1	413.9	52.0	100.0	18.7	69.9	67.1	313.9	100.4	344.0	76	83
5-17 to 5-23-72	6.5	420.4	1.0	101.0	1.1	71.0	5.5	319.4	5.4	349.4	76	83
5-23 to 6-2-72	9.8	430.2	4.7	105.7	4.2	75.2	5.1	324.5	5.6	355.0	75	82
6-2 to 6-21-72	46.8	477.0	12.6	118.3	356.3**	431.5	34.2	358.7	-309.5	45.5	75	10**
6-21 to 8-9-72	55.0	532.0	36.0	154.3	15.0	446.5	19.0	377.7	40.0	85.5	71	16**
8-9 to 8-30-72	43.8	575.8	26.1	180.4	11.0	457.5	17.7	395.4	32.8	118.3	69	21**
8-30 to 10-2-72	42.1	617.9	13.5	193.9	10.7	468.2	28.6	424.0	31.4	149.7	69	24**
10-2 to 10-26-72	57.0	674.9	7.0	200.9	8.6	476.8	50.0	474.0	48.4	198.1	70	29**

* Reduction relative to control plot.

**Assuming that the 356.3 lb. of sediment eroded from Plot 3 was due to unusual circumstances and substituting 12.6 lb. (same as quantity from Plot 1) the % reduction for the rest of the experiment is as follows: 6-21 82%; 8-9 81%; 8-30 80%; 10-2 80%; 10-26 80%. See text for explanation.

TABLE B

EROSION AND PRECIPITATION

Period	Prec. Type	Prec. (Inches)	Accum. Prec. (Inches)	Sediment (lbs.) Plot 1 (Curasol)	Plot 2 (Control)	Plot 3 (Aerospray)	Total Accum. Sed. (lbs.) Plot 1 (Curasol)	Plot 2 (Control)	Plot (Aerospr
10-15 to 10-27-71	Snow	.15	.15	3.5	50.8	6.6	3.5	50.8	6.6
10-27 to 11-10	Snow	.07	.22	16.3	131.5	23.7	19.8	182.3	30.3
11-10 to 11-18	Rain & Snow	1.55	1.77	5.6	22.2	6.3	25.4	204.5	36.6
11-18 to 12-7	Rain & Snow	3.00	4.77	2.4	2.1	1.6	27.8	206.6	38.2
Test plots were covered with snow between 11-18-71 and early March 1972. In early March the sediment troughs were damaged by the melting snow and the eroded sediment was not collected. The troughs were repaired and in service on 3-10-72.									
12-7-71 to 3-10-72	Rain & Snow	13.02	17.79	Sediment was not collected					
3-10 to 3-21	1 ---	0	17.79	1.7	17.1	3.3	29.5	223.7	41.5
3-21 to 3-28	Rain & Snow	.88	18.67	6.5	25.0	3.4	36.0	248.7	44.9
3-28 to 4-21	Rain & Snow	2.03	20.70	12.0	46.1	6.3	48.0	294.8	51.2
4-21 to 5-17	Rain & Snow	.15	20.85	52.0	119.1	18.7	100.0	413.9	69.9
5-17 to 5-23	Rain & Snow	.66	21.51	1.0	6.5	1.1	101.0	420.4	71.0
5-23 to 6-2	Rain	.46	21.97	4.7	9.8	4.2	105.7	430.2	75.2
6-2 to 6-21	Rain	2.75	24.72	12.6	46.8	*356.3	118.3	477.0	431.5
6-21 to 8-9	Rain	.02	24.74	36.0	55.0	15.0	154.3	532.0	446.5
8-9 to 8-30	Rain	.26	25.00	26.1	43.8	11.0	180.4	575.8	457.5
8-30 to 10-2	Rain	2.58	27.58	13.5	42.1	10.7	193.9	617.9	468.2
10-2 to 10-26	Rain	1.77	29.35	7.0	57.0	8.6	200.9	674.9	476.8

*See text for explanation.

TABLE C

DAILY PRECIPITATION RECORD (INCHES OF WATER)

Day of Month	Oct. (1971)	Nov. (1971)	Dec. (1971)	Jan. (1972)	Feb. (1972)	Mar. (1972)	Apr. (1972)	May (1972)	June (1972)	July (1972)	Aug. (1972)	Sept. (1972)	Oct. (1972)
1	-	0	0	0	0	0	0	0	0	0	0	.22R	.46R
2	-	0	0.45S	0	0	.44R	0	0	0	0	0	.01R	.34R
3	-	0	0.25S	0	0	.50R	0	0	0	0	0	0	0
4	-	0	0.01S	0	.12S	0	.06R	0	1.79R	0	0	0	0
5	-	0	0	0	.18S	0	.50R,S	0	.20R	0	0	.25R	0
6	-	0	0.15S	0	0	0	.53R	0	.06R	0	0	0	0
7	-	0	0	0	0	0	.01R	0	.33R	0	0	0	.13R
8	-	0	0	0	0	0	.02R	.01R	.09R	0	0	0	.01R
9	-	0	0.21S	0	0	0	0	0	.04R	0	0	0	.06R
10	-	0	0.41S	0	0	.02R,S	0	0	.07R	0	0	0	.03R
11	-	1.23S	0.08S	0	0	0	0	0	0	0	0	0	0
12	-	0.13S	0.82S	0	0	0	0	0	0	0	0	0	0
13	-	0.19S	0.01S	0	0	0	.34S	0	0	0	0	0	0
14	-	0	0.04S	0	0	0	.56S	0	0	0	0	0	.04R
15	*	0	0.02S	0	0	0	0	0	0	0	0	0	.03R
16	0.15S	0	0	0	0	0	0	0	0	0	0	0	.13R
17	0	0	0	0	0	0	0	0	.17R	0	0	0	0
18	0	0.01S	0	0	0	0	.01S	0	0	0	0	0	.83R
19	0	0	0	.08S	0	0	0	.44S	0	0	0	0	.32R
20	0	0	0	0	0	0	0	.17S	0	.02R	0	0	.19R
21	0	0	0.38S	.07R	.17S	0	0	.05R,S	0	0	0	0	0
22	0	0	2.00S	.14S	.39S	.64S	0	0	0	0	0	0	0
23	0	0	0.38S	.33S	0	.01S	0	0	0	0	0	0	0
24	0	0	1.08S	0	.40S	.07R	.14S	0	0	0	0	0	0
25	0	0	2.18S	.45S	.33S	.16R	0	0	0	0	0	.09R	0
26	0	0.53R	0.01S	.16S	.02S	0	0	.46R	0	0	0	.64R	0
27	0.03S	0.09S	0.22S	1.01S	0	0	0	0	0	0	0	.54R	0
28	0	1.35S	0	.02S	.15R	0	0	0	0	0	0	.01R	0
29	0	0.17S	0	0	.20S	0	0	0	0	0	.20R	0	0
30	0.04S	0	0	0		0	0	0	0	0	.06R	0	0
31	0		0	0		0		0		0	.02R		0
Total	0.22	3.70	8.70	2.26	1.96	1.84	2.17	1.13	2.75	.02	.28	1.76	2.57

R = Rain - S = Snow (Measured in inches of water)
*Precipitation Gage placed in operation

Total Precipitation 10-15-71 to 10-15-72
= 27.89 Inches

TABLE D
SEVERE RAINFALL INTENSITY (>0.10 Inch/Hr.) RECORD

Date	Time Interval (Hours)	Precip. (Inches)	Duration (Hours)	Intensity (Inches/Hr.)
11-11-71	0235 - 0245	.02	.17	.12
11-11	0345 - 0440	.13	.92	.14
11-11	0510 - 0635	.30	1.42	.21
11-11	0750 - 0800	.02	.16	.13
11-11	0830 - 0930	.15	1.00	.15
11-11	1150 - 1305	.23	1.25	.18
11-11	1355 - 1400	.02	.08	.25
11-11	1905 - 1915	.03	.17	.18
4-6-72	0980 - 1425	.53	4.45	.12
5-26	1700 - 1750	.46	.50	.92
6-4	1490 - 1750	1.55*	2.60	.60
6-4	1750 - 1950	.24*	2.00	.12
6-5	2230 - 2260	.08	.30	.27
6-6	1640 - 1660	.04	.20	.20
6-7	1190 - 1210	.06	.20	.30
6-7	1770 - 1820	.15	.50	.30
6-8	1250 - 1260	.02	.10	.20
6-17	1700 - 1750	.12	.50	.24
8-29	1580 - 1620	.17	.40	.43
8-30	1400 - 1430	.04	.30	.13
9-1	1750 - 1880	.22	1.30	.17
9-5	0330 - 0370	.23	.40	.58
9-26	0110 - 0380	.36	2.70	.13
9-26	0540 - 0590	.13	.50	.26
9-27	0020 - 0050	.07	.30	.23
9-27	0110 - 0250	.18	1.40	.13
10-1	2110 - 2210	.24	1.00	.24
10-2	1700 - 1790	.29	.90	.32
10-7	1150 - 1160	.02	.10	.20
10-18	0960 - 1130	.23	1.70	.14
10-19	1450 - 1490	.07	.40	.18

*Possibly including some hail.